

INTRODUCTION

Treatment planning and optimization for head and neck cancer is an iterative and time consuming task¹. Even the clinically accepted plans for the same treatment site and institution differ in plan quality specifically in OAR sparing. Many different solutions have been proposed to automate the treatment plan optimization to achieve superior quality plans and to reduce the human intervention^{2,3}. Recently an auto-planning module termed as "Personalized planning" was introduced in Pinnacle treatment planning system. Personalized planning (PP) module includes a modified template-based auto-planning optimization engine constructed on Broyden-Fletcher-Goldfarb-Shanno (LBFGS) and Layered Graph algorithms⁴.

AIM

This study was aimed to:

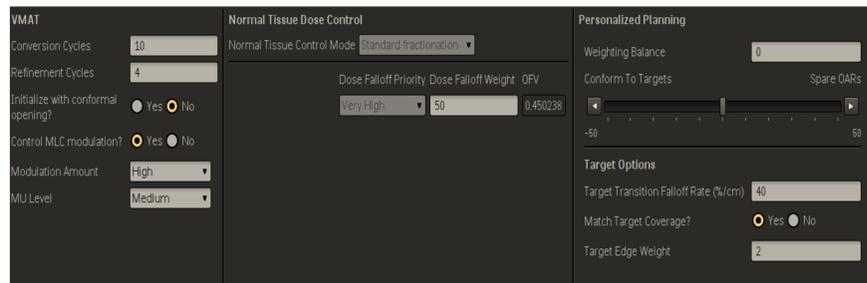
1. Comprehensively evaluate "personalized planning module in Pinnacle TPS for complex head and neck treatments;
2. Compare the quality of plans from personalized planning module to the plans generated by RayStation TPS.

METHODS

- Ten HN patients with oropharyngeal disease treated between 2019-2021 were selected respectively for this IRB approved study. All patients had primary target volumes and bilateral lymph nodes treated with a prescription of 70 Gy and 56 Gy respectively.
- The clinical plans were prepared with VMAT technique in Pinnacle (v. 16.2) using 6 MV energy from truebeam linear accelerator. All plans had three full arcs and collimator angles of $\pm 10^\circ$ and 90° . The dose was calculated using collapse-cone convolution superposition algorithm with 4° control spacing and 4 mm isotropic dose grid.
- The patients were re-planned using Pinnacle TPS (v. 16.4) and RayStation TPS (v. 10B).
- **Personalized planning:** The module integrates a recently develop optimization algorithm with user-defined planning settings termed as "treatment technique". In this work, treatment technique was developed in consultation with the vendor to achieve reasonable dose gradients and plan complexity as shown in figure 1. The planner is not allowed to set the number of iterations. Instead, the dose computation and optimization iterations are designed in successive loops pre-entered by user in the fields of conversion and refinement cycles. The minimum segment area was set at 25 cm² with medium monitor unit levels to achieve a moderate level of plan complexity. The normal tissue control defines the priority for the dose fall off around the targets. High priority was selected to achieve fast dose gradients.

- **Planning in RayStation:** the plans were prepared on a non-clinical GPU-based workstation (research version). This study does not include multi-criteria optimization. All plans were optimized manually.
- The optimization was initiated after specifying the targets and organs-at-risk (OAR) with desired dose goals and objectives. For both Pinnacle and RayStation, the optimization was continued until the desired plan was achieved.
- The plans were normalized such that for both PTVs: $V_{Rx} \geq 95\%$, $V_{73.5Gy} < 15\%$ and plan maximum dose ($D_{0.03cc}$) $< 77Gy$.
- The doses received by the OARs in clinical plans (CP), personalized plans (PP) and RayStation plans (RS) were evaluated using our institutional criteria listed in table 1 for selected OARs.
- EPID based pre-treatment QA was performed for nine PP plans to assess the delivery accuracy.

Figure 1: Treatment technique used to optimize the "head and neck" plans



RESULTS

- The dose coverage to both high and low dose PTVs was comparable among all plans.
 - The average V_{Rx} for PTV 70 was $97.7 \pm 1.0\%$, $97.0 \pm 0.9\%$ and $95.3 \pm 0.4\%$ for CP, PP and RS plans respectively.
 - The average V_{Rx} for PTV 56 was $96.5 \pm 0.4\%$, $96.4 \pm 0.6\%$ and $95.2 \pm 0.2\%$ for CP, PP and RS plans respectively.
 - The average plan maximum dose was $75.1 \pm 1.0 Gy$, $75.1 \pm 0.7 Gy$ and $75.9 \pm 1.0 Gy$ for CP, PP and RS plans respectively.
- As shown in table 1, the doses received by the OARs for PP and RS plans were complying our institutional criteria and were found comparable with the clinical plans. Figure 1 shows a dose-volume histogram comparison for spinal cord and targets for patient #1.
- The largest difference in the OAR average dose for PP plans from both CP and RS plans was found for lips. The average dose was also found higher than the ideal institutional goal. However mean dose to lips up to 20 Gy was found acceptable at our institution.
- All delivered PP plans passed the γ -analysis at 3%/2 mm with average passing rates of $99.4 \pm 0.8\%$.

Table 1: Descriptive statistics for the selected OARs.

OAR	Average Dose (Gy)			
	Goal	CP	PP	RS
Brainstem	$D_{0.03cc} < 25 Gy$	11.3±2.7	15.1±4.7	16.6±5.6
Spinal Cord	$D_{0.03cc} < 35 Gy$	21.7±4.4	23.5±4.9	24.8±4.5
Left Parotid	$D_{mean} < 24 Gy$	18.2±4.9	19.3±3.7	20.7±4.4
Right Parotid	$D_{mean} < 24 Gy$	19.7±5.3	20.6±4.5	20.9±3.8
Larynx	$D_{mean} < 30 Gy$	22.1±5.4	23.3±5.5	22.4±4.5
Supraglottis	$D_{mean} < 45 Gy$	36.5±11.8	37.4±11.2	36.5±9.6
OARPharynx	$D_{mean} < 45 Gy$	42.2±4.9	42.6±3.3	44.0±2.6
Trachea	$D_{mean} < 25 Gy$	15.6±5.2	16.7±4.5	16.3±3.9
Esophagus	$D_{mean} < 25 Gy$	11.5±4.7	13.3±5.1	12.0±4.0
Oral Cavity	$D_{mean} < 30 Gy$	30.0±2.9	31.6±2.1	31.2±2.8
Lips	$D_{mean} < 7 Gy$	7.2±2.0	11.8±3.0	8.6±1.2

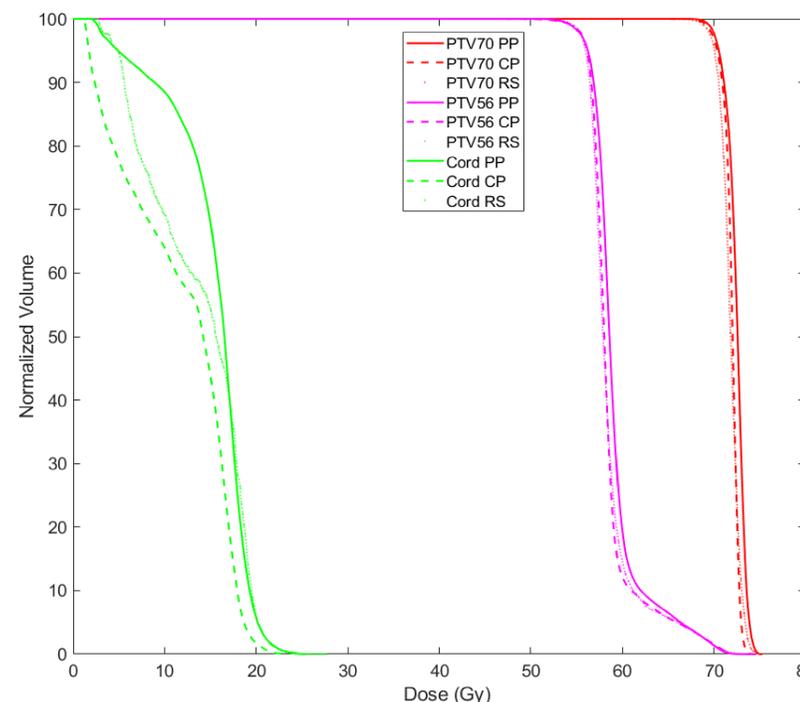


Figure 2: Comparison of dose-volume histograms for both targets and spinal cord among the clinical, personalized planning and RayStation plans for patient #1.

CONCLUSIONS

- Personalized planning module in Pinnacle TPS resulted in the plan quality comparable to the previous treated clinical plans and plans generated by the RayStation TPS.
- The coverage to the high and low dose PTVs with the respective prescription doses were found comparable.
- The average doses to most of the OARs for personalized planning plans were found comparable to those of the clinical and RayStation plans.
- The largest difference of the OAR dose in PP plans in comparison to the CP and RS plans were found for lips.
- All personalized plans were found deliverable with average gamma passing rates of $99.4 \pm 0.8\%$ at a level of 3%/2mm with global normalization and 10% low dose threshold.

ACKNOWLEDGEMENTS

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CONTACT INFORMATION

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